

Detailed Computational Results

EC.1. Proof of Theorem 3

Proof of Theorem 3. If $\xi t \leq 1$ defines facet of $\mathcal{P}_{\text{MKP}}(W_i)$ there are W_i affinely independent points p^j , $j = 1, \dots, |W_i|$, satisfying $\xi p^j = 1$. Then $(p^j, 1)$, $j = 1, \dots, |W_i|$, and $(\mathbf{0}, 0)$ are $W_i + 1$ affinely independent points satisfying $\xi\theta = y_i$.

If $\xi\theta \leq y_i$ defines a facet of $\text{conv}\{(\theta^i, y_i) \in \mathbb{Z}_+^{W_i} \times \{0, 1\} : \sum_{q=1}^{W_i} q\theta_q \leq W_i y_i\}$ there are $W_i + 1$ affinely independent integer points satisfying $\xi\theta = y_i$. One of those points is certainly $(\mathbf{0}, 0)$, the remaining points have the format $(p^j, 1)$, $j = 1, \dots, |W_i|$. Then, p^j , $j = 1, \dots, |W_i|$, are W_i affinely independent points satisfying $\xi\theta = 1$. \square

EC.2. Detailed results for LRP

In the following tables, BKS stands for the best-known solution, IPB for the initial primal bound, RDB for the root dual bound, Rg for the root gap, Rt for the time spent in the root node, Nodes for the number of nodes explored in the branch-and-bound tree, Fg for the final gap, BPB for the best primal bound, and t for the total time. New best solutions are in bold.

In Table EC.1, the IPB values that were already proven to be optimal are labeled with *. Nine instances were solved to optimality for the first time. In two cases the optimal solutions improve upon the previous best-known solutions. Table EC.2 are similar experiments, but without using IPBs. The results show that one less instance is solved. For the 24 instances solved in both ways, the geometric mean of the running times increases from 238 seconds to 628 seconds, a factor of 2.6. It is clear that external bounds do help the BCP algorithm, but they are not essential for overall performance. Table EC.3 and Table EC.4 are comparisons with Contardo et al. (2014), using the same IPBs. Finally, Table EC.5 are results on the new Schneider and Löffler (2019) instances, using the best-known solutions in the literature as IPBs.

Table EC.1: Detailed results for algorithm BCP_{all} initialized with the best known primal bounds in the literature on instances PPW06

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)
coord50-5-1	90111*	0.00%	8	1	0.00%	90111	7
coord50-5-1b	63242	0.00%	84	1	0.00%	63242	83
coord50-5-2	88298*	2.22%	10	3	0.00%	88298	14
coord50-5-2BIS	84055*	0.00%	5	1	0.00%	84055	5
coord50-5-2b	67308*	2.37%	74	3	0.00%	67308	174
coord50-5-2bBIS	51822*	0.00%	8	1	0.00%	51822	7
coord50-5-3	86203*	0.00%	19	1	0.00%	86203	18
coord50-5-3b	61830*	0.00%	38	1	0.00%	61830	37
coord100-10-1	287661	1.04%	161	55	0.00%	287661	2683
coord100-10-1b	230989	0.43%	360	13	0.00%	230989	2025
coord100-10-2	243590*	1.07%	153	9	0.00%	243590	660
coord100-10-2b	203988*	0.35%	457	3	0.00%	203988	936
coord100-10-3	250882	2.24%	137	33	0.00%	250882	1591
coord100-10-3b	203114	1.56%	214	31	0.00%	203114	11173
coord100-5-1	274814*	0.00%	32	1	0.00%	274814	31
coord100-5-1b	213568*	0.16%	272	3	0.00%	213568	393
coord100-5-2	193671*	0.00%	19	1	0.00%	193671	18
coord100-5-2b	157095*	0.00%	157	1	0.00%	157095	156
coord100-5-3	200079*	0.00%	64	1	0.00%	200079	63
coord100-5-3b	152441*	0.00%	90	1	0.00%	152441	90
coord200-10-1	474850	0.25%	481	21	0.00%	474702	1949
coord200-10-1b	375177	0.09%	2842	5	0.00%	375177	4354
coord200-10-2	448077	0.27%	586	213	0.00%	448005	20961
coord200-10-2b	373696	0.12%	1907	9	0.00%	373696	6633
coord200-10-3	469433*	0.07%	472	3	0.00%	469433	578
coord200-10-3b	362320	0.39%	1755	135	0.21%	362320	107998

Table EC.2: Detailed results for algorithm BCP_{all} executed on instances PPW06 without initial upper bound

Instance	BKS	RDB	Rt (s)	Nodes	Fg (%)	BPB	t (s)
coord50-5-1	90111	89853	15	3	0.00%	90111	38
coord50-5-1b	63242	62604	53	5	0.00%	63242	284
coord50-5-2	88298	86315	15	5	0.00%	88298	82
coord50-5-2BIS	84055	83875	17	3	0.00%	84055	74
coord50-5-2b	67308	65397	34	5	0.00%	67308	274
coord50-5-2bBIS	51822	51763	20	3	0.00%	51822	41
coord50-5-3	86203	85360	17	3	0.00%	86203	60
coord50-5-3b	61830	61329	38	3	0.00%	61830	99
coord100-10-1	287661	284453	93	79	0.00%	287661	4258
coord100-10-1b	230989	229802	177	15	0.00%	230989	3760
coord100-10-2	243590	240915	97	11	0.00%	243590	795
coord100-10-2b	203988	202990	198	7	0.00%	203988	1393
coord100-10-3	250882	245041	96	129	0.00%	250882	5630
coord100-10-3b	203114	199867	161	39	0.00%	203114	11517
coord100-5-1	274814	273995	29	3	0.00%	274814	79
coord100-5-1b	213568	212635	72	15	0.00%	213568	1620
coord100-5-2	193671	193506	37	3	0.00%	193671	63
coord100-5-2b	157095	156758	123	5	0.00%	157095	400
coord100-5-3	200079	199503	55	7	0.00%	200079	248
coord100-5-3b	152441	152344	191	3	0.00%	152441	355
coord200-10-1	474702	473451	290	57	0.00%	474702	7732
coord200-10-1b	375177	373958	956	31	0.00%	375177	19457
coord200-10-2	448077	446558	330	901	0.30%	448475	107995
coord200-10-2b	373696	372523	715	51	0.00%	373696	29804
coord200-10-3	469433	468846	389	9	0.00%	469433	2274

coord200-10-3b 362320 360656 996 43 – – 108148

Table EC.3: Detailed comparison between algorithm BCP_{all} and the approach by Contardo et al. (2014) on instances PPW06

Instance	IPB	BCP_{best}						Contardo et al. (2014)	
		Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)	BPB	t (s)
coord50-5-1	90111	0.00%	8	1	0.00%	90111	7	90111*	9
coord50-5-1b	63242	0.00%	83	1	0.00%	63242	83	63242*	243
coord50-5-2	88298	2.22%	10	3	0.00%	88298	14	88298*	7
coord50-5-2BIS	84055	0.00%	5	1	0.00%	84055	5	84055*	15
coord50-5-2b	67340	2.42%	74	3	0.00%	67308	179	67308*	226
coord50-5-2bBIS	51822	0.00%	8	1	0.00%	51822	8	51822*	4
coord50-5-3	86203	0.00%	19	1	0.00%	86203	19	86203*	48
coord50-5-3b	61830	0.00%	37	1	0.00%	61830	37	61830*	3
coord100-10-1	289017	1.52%	140	117	0.00%	287661	5259	289017	23543
coord100-10-1b	234641	2.01%	259	15	0.00%	230989	4092	234641	19351
coord100-10-2	243590	1.07%	149	7	0.00%	243590	516	243590*	1144
coord100-10-2b	203988	0.35%	454	3	0.00%	203988	931	203988*	165
coord100-10-3	252421	2.85%	134	123	0.00%	250882	5255	252421	12656
coord100-10-3b	204597	2.28%	200	285	0.00%	203114	71156	204597	40740
coord100-5-1	274814	0.00%	31	1	0.00%	274814	31	274814*	227
coord100-5-1b	214392	0.65%	188	7	0.00%	213568	814	213568	24306
coord100-5-2	193671	0.00%	19	1	0.00%	193671	18	193671*	29
coord100-5-2b	157173	0.15%	163	3	0.00%	157095	229	157095*	6389
coord100-5-3	200079	0.00%	65	1	0.00%	200079	64	200079*	63
coord100-5-3b	152441	0.00%	89	1	0.00%	152441	89	152441*	239
coord200-10-1	479425	1.22%	364	101	0.00%	474702	13293	479425	25298
coord200-10-1b	378773	1.17%	1529	37	0.00%	375177	20533	378773	120447

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)	BPB	t (s)
coord200-10-2	450468	0.82%	423	1049	0.28%	448409	107997	450468	15871
coord200-10-2b	374435	0.35%	1369	81	0.00%	373696	41884	374435	46988
coord200-10-3	472898	0.84%	488	17	0.00%	469433	3341	469433*	9519
coord200-10-3b	364178	0.95%	1162	91	0.71%	364178	108107	364178	22867

Table EC.4: Detailed comparison between algorithm BCP_{best} and the approach by Contardo et al. (2014) on instances **TB99**

Instance	IPB	BCP_{best}						Contardo et al. (2014)	
		Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)	BPB	t (s)
coordP111112	1467.68	0.00%	136	1	0.00%	1467.68	134	1467.68*	2269
coordP111212	1394.80	0.36%	315	3	0.00%	1394.80	521	1394.80*	10947
coordP112112	1167.16	0.00%	257	1	0.00%	1167.16	256	1167.16*	158
coordP112212	791.66	0.00%	398	1	0.00%	791.66	397	791.66*	934
coordP113112	1245.45	1.92%	2442	19	0.00%	1238.24	28648	1238.24	87225
coordP113212	902.26	0.00%	130	1	0.00%	902.26	129	902.26*	78
coordP131112	1900.70	0.57%	1500	5	0.00%	1892.17	3628	1896.98	177697
coordP131212	1965.12	0.77%	698	19	0.00%	1960.02	9097	1965.12	128169
coordP132112	1443.33	0.00%	696	1	0.00%	1443.32	693	1443.32*	9451

Table EC.5: Detailed results for algorithm BCP_{all} initialized with best known primal bounds in the literature on instances **SL19**

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)
100-5-1c	134516	0.00%	20	1	0.00%	134516	19

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)
100-5-1d	275749	0.32%	48	5	0.00%	275749	121
100-5-1e	292311	0.00%	41	1	0.00%	292301	40
100-5-2c	83989	0.16%	9	1	0.00%	83855	9
100-5-2d	242266	0.88%	67	3	0.00%	242105	134
100-5-2e	253888	0.30%	84	9	0.00%	253888	253
100-5-3c	87555	0.00%	12	1	0.00%	87555	11
100-5-3d	226783	0.07%	56	1	0.00%	226634	55
100-5-3e	252603	0.00%	50	1	0.00%	252603	50
100-5-4a	255853	0.00%	30	1	0.00%	255853	29
100-5-4b	214425	0.00%	94	1	0.00%	214425	94
100-5-4c	98129	0.53%	59	5	0.00%	98104	124
100-5-4d	250315	0.16%	61	5	0.00%	250301	99
100-5-4e	211159	0.85%	116	479	0.00%	211113	15045
100-10-1c	92629	0.00%	17	1	0.00%	92629	16
100-10-1d	363930	0.50%	90	31	0.00%	363930	1176
100-10-1e	344322	0.54%	191	11	0.00%	344322	536
100-10-2c	84717	0.00%	17	1	0.00%	84717	16
100-10-2d	343252	1.14%	88	53	0.00%	343252	2404
100-10-2e	332900	0.20%	186	3	0.00%	332900	275
100-10-3c	85618	0.29%	41	1	0.00%	85369	40
100-10-3d	329990	1.28%	78	443	0.00%	329990	13177
100-10-3e	318156	0.88%	167	29	0.00%	318109	1508
100-10-4a	253892	0.69%	262	9	0.00%	253471	607
100-10-4b	211354	0.65%	743	5	0.00%	211354	2154
100-10-4c	86215	0.00%	31	1	0.00%	86215	30
100-10-4d	328251	1.35%	117	2267	0.00%	328181	74215
100-10-4e	308866	0.55%	196	455	0.00%	308757	19460
200-10-1c	156087	0.34%	325	5	0.00%	156029	564
200-10-1d	638452	0.40%	398	111	0.00%	638068	10811
200-10-1e	599463	0.86%	694	141	0.00%	599069	14871

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)
200-10-2c	144337	0.51%	379	83	0.00%	144046	8427
200-10-2d	663814	0.46%	586	823	0.23%	663154	107995
200-10-2e	619037	0.25%	1381	467	0.00%	618858	53043
200-10-3c	184885	0.06%	458	1	0.00%	184783	452
200-10-3d	640357	0.06%	451	3	0.00%	640289	587
200-10-3e	604617	0.13%	1019	95	0.00%	604480	9448
200-10-4a	452870	0.99%	868	835	0.00%	452430	85744
200-10-4b	369951	0.78%	2284	135	0.43%	369871	107997
200-10-4c	144407	0.46%	400	125	0.00%	144013	10930
200-10-4d	618590	0.34%	499	297	0.00%	617932	37803
200-10-4e	562854	0.36%	1114	893	0.25%	562854	107995
200-15-1a	461203	0.38%	748	153	0.00%	460430	18752
200-15-1b	367397	0.54%	1872	113	0.00%	366359	67910
200-15-1c	148218	0.05%	134	1	0.00%	148141	127
200-15-1d	813941	0.24%	424	25	0.00%	813576	2225
200-15-1e	708837	2.15%	686	1181	0.26%	708585	107993
200-15-2a	513893	1.97%	608	211	0.00%	513512	21920
200-15-2b	406843	0.50%	2187	137	0.18%	406839	107992
200-15-2c	135051	0.30%	316	3	0.00%	134779	336
200-15-2d	811722	0.29%	776	41	0.00%	811361	4805
200-15-2e	712524	0.56%	877	649	0.34%	712524	107993
200-15-3a	455676	0.53%	1249	151	0.00%	455351	20594
200-15-3b	357086	0.55%	2668	65	0.00%	356887	71800
200-15-3c	141129	0.56%	475	11	0.00%	140765	1216
200-15-3d	877638	0.31%	574	111	0.00%	877543	13590
200-15-3e	816377	2.73%	828	809	2.23%	816129	107994
200-15-4a	433268	0.44%	668	513	0.00%	432672	51175
200-15-4b	349269	0.91%	1896	137	0.50%	349269	107994
200-15-4c	143772	0.81%	570	27	0.00%	143052	3196
200-15-4d	828144	0.22%	473	179	0.00%	826829	33505

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)
200-15-4e	700202	1.53%	1649	79	0.00%	700013	13447
300-15-1a	856267	0.66%	3135	389	0.25%	854503	107989
300-15-1b	622412	0.91%	9755	5	0.62%	622412	108004
300-15-1c	366770	0.70%	1124	35	0.00%	364979	6341
300-15-1d	1339010	0.47%	1582	409	0.33%	1338255	107987
300-15-1e	1217690	1.34%	2645	275	0.63%	1217690	107989
300-15-2a	759999	1.02%	3283	331	0.21%	757931	107990
300-15-2b	557912	0.60%	16604	13	0.44%	557912	107996
300-15-2c	311558	0.79%	1001	437	0.00%	310061	69751
300-15-2d	1301863	0.38%	1748	469	0.15%	1301210	107984
300-15-2e	1272700	0.70%	3191	371	0.62%	1272700	107983
300-15-3a	778023	0.36%	3311	39	0.00%	776531	20139
300-15-3b	594073	0.32%	23608	3	0.30%	594073	115651
300-15-3c	341712	0.64%	1931	23	0.00%	340155	5450
300-15-3d	1358223	0.83%	2162	261	0.66%	1358223	108036
300-15-3e	1286877	0.55%	4233	289	0.46%	1286877	108007
300-15-4a	747730	0.24%	3488	109	0.00%	746407	22202
300-15-4b	559877	0.54%	6247	45	0.47%	559877	107982
300-15-4c	304254	0.89%	1842	55	0.00%	302390	15149
300-15-4d	1288091	0.44%	2045	305	0.19%	1285714	107990
300-15-4e	1173516	1.92%	2362	221	0.58%	1173516	107989
300-20-1a	1009840	6.86%	3018	107	6.76%	1009840	108004
300-20-1b	739604	0.81%	12842	45	0.63%	739604	108023
300-20-1c	364096	0.92%	1502	21	0.00%	361735	6084
300-20-1d	1575390	0.50%	2601	353	0.23%	1572968	107978
300-20-1e	1391567	7.97%	1769	137	1.61%	1320811	107990
300-20-2a	909306	1.14%	4364	287	0.65%	909306	107979
300-20-2b	695524	0.86%	9876	23	0.46%	695524	108011
300-20-2c	299425	0.58%	1735	33	0.00%	298522	8333
300-20-2d	1569139	0.54%	2623	257	0.45%	1569042	107982

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)
300-20-2e	1386386	7.88%	2043	107	7.75%	1386386	108070
300-20-3a	929901	0.80%	3786	149	0.00%	927452	62525
300-20-3b	751307	0.75%	11312	3	0.75%	751307	108014
300-20-3c	305771	0.88%	1846	71	0.00%	304269	23007
300-20-3d	1539008	0.65%	3376	215	0.54%	1539008	107977
300-20-3e	1289734	3.46%	3968	93	3.20%	1289734	107992
300-20-4a	859474	2.24%	3061	135	1.45%	859474	107979
300-20-4b	687930	1.09%	7554	25	0.91%	687930	108003
300-20-4c	300285	1.04%	1606	391	0.59%	299206	107981
300-20-4d	1540194	0.59%	2868	115	0.47%	1540194	108021
300-20-4e	1344056	3.17%	2578	103	2.72%	1344056	107983

EC.3. Detailed results for VRP-CMD

In the following tables, IPB stands for the initial primal bound, Rg for the root gap, Rt for the time spent in the root node, Nodes for the number of nodes explored in the branch-and-bound tree, Fg for the final gap, BPB for the best primal bound, and t for the total time.

Table EC.6 contains instances for which the initial primal bound is the optimal solution.

Table EC.6: Detailed results for algorithm BCP_{all} for 183 instances of the VRP-CMD with known optimal solutions

Instance	Rg (%)	Rt (s)	Nodes	OPT	t (s)
MDCVRP-10	4.91%	21	67	12173.31	556
MDCVRP-34	0.40%	40	237	8926.51	3434
MDCVRP-60	9.87%	20	105	10372.76	763
MDCVRP-62	4.50%	27	5	9106.99	44
MDCVRP-74	5.60%	13	17	11038.03	291

Instance	Rg (%)	Rt (s)	Nodes	OPT	t (s)
MDCVRP-96	5.88%	15	39	10986.37	1293
MDCVRP-97	8.02%	17	99	11581.48	1521
MDCVRP-99	9.61%	17	25	12139.98	413
MDCVRP-103	0.17%	31	21	9121.74	1276
MDCVRP-126	3.32%	27	61	11113.19	2545
MDCVRP-130	3.17%	35	9	10426.02	137
MDCVRP-157	5.74%	15	23	11070.27	870
MDCVRP-169	5.35%	23	241	11562.64	3057
MDCVRP-171	5.38%	19	13	11534.90	176
MDCVRP-174	6.13%	19	231	10373.74	2786
MDCVRP-236	4.86%	12	13	8501.00	173
MDCVRP-250	0.19%	13	3	9796.07	15
MDCVRP-302	3.36%	25	13	9771.93	604
MDCVRP-326	0.12%	45	5	18741.80	68
MDCVRP-327	5.98%	16	91	21225.95	4246
MDCVRP-339	8.92%	19	45	22367.17	466
MDCVRP-387	3.23%	37	41	19946.78	606
MDCVRP-390	3.39%	31	19	19986.70	242
MDCVRP-395	3.14%	24	43	21249.03	1298
MDCVRP-421	5.79%	13	29	21224.26	257
MDCVRP-423	5.78%	14	21	21245.60	401
MDCVRP-425	4.60%	28	49	18710.86	1371
MDCVRP-439	5.86%	16	29	21190.06	602
MDCVRP-464	5.86%	15	53	21199.69	1042
MDCVRP-470	0.11%	45	3	18730.92	66
MDCVRP-488	0.80%	21	13	20116.83	917
MDCVRP-502	0.52%	24	27	20104.00	1116
MDCVRP-587	5.87%	12	29	21238.92	934
MDCVRP-613	3.05%	24	19	21311.24	1960
MDCVRP-622	7.59%	29	139	11037.13	2514

Instance	Rg (%)	Rt (s)	Nodes	OPT	t (s)
MDCVRP-632	3.59%	11	9	9146.32	400
MDCVRP-639	8.95%	33	111	10380.29	849
MDCVRP-641	2.52%	38	25	10480.34	2146
MDCVRP-658	8.70%	14	15	7171.93	386
MDCVRP-685	4.98%	25	69	11024.04	1086
MDCVRP-707	6.46%	18	19	9730.32	282
MDCVRP-734	3.26%	32	9	9755.94	472
MDCVRP-737	5.88%	13	63	7224.22	1342
MDCVRP-738	0.48%	24	357	7225.52	6935
MDCVRP-739	0.10%	68	7	7213.34	126
MDCVRP-750	5.30%	26	53	11050.04	1062
MDCVRP-756	7.79%	34	199	10360.89	1766
MDCVRP-803	0.11%	33	5	17427.52	303
MDCVRP-822	0.56%	53	17	6514.35	619
MDCVRP-1000	0.37%	41	9	9039.34	175
MDCVRP-1002	8.44%	35	273	10943.38	2968
MDCVRP-1025	6.69%	29	113	11452.94	1338
MDCVRP-1041	7.29%	21	61	11565.85	826
MDCVRP-1165	8.03%	36	187	10846.28	4080
MDCVRP-1172	0.23%	43	17	8401.45	1185
MDCVRP-1238	0.36%	37	453	9021.62	7184
MDCVRP-1253	7.94%	38	187	21046.28	3273
MDCVRP-1262	0.24%	44	53	17418.74	787
MDCVRP-1268	3.45%	50	3	17335.24	57
MDCVRP-1279	0.62%	48	37	18770.68	642
MDCVRP-1284	8.66%	34	373	21010.83	3452
MDCVRP-1286	4.14%	52	3	17335.31	71
MDCVRP-1293	0.17%	50	19	18638.32	221
MDCVRP-1299	1.88%	23	75	18548.08	1352
MDCVRP-1300	3.02%	32	79	19840.65	4078

Instance	Rg (%)	Rt (s)	Nodes	OPT	t (s)
MDCVRP-1305	2.54%	18	81	17356.16	1835
MDCVRP-1318	3.25%	31	3	18526.70	45
MDCVRP-1359	3.85%	29	9	21081.58	174
MDCVRP-1364	5.37%	19	7	20990.38	85
MDCVRP-1368	3.47%	34	3	17407.77	41
MDCVRP-1370	3.14%	35	3	18664.96	42
MDCVRP-1411	2.22%	36	9	19790.23	176
MDCVRP-1465	7.66%	31	29	20987.81	1380
MDCVRP-1489	5.09%	23	25	21047.19	328
MDCVRP-1582	0.56%	40	29	7087.31	1007
MDCVRP-1612	5.66%	14	3	7034.78	40
MDCVRP-1614	0.25%	70	25	6451.33	536
MDCVRP-1617	4.26%	21	23	7085.51	343
MDCVRP-1663	4.26%	11	9	9661.81	425
MDCVRP-1687	0.42%	39	101	7833.00	2030
MDCVRP-1738	3.97%	12	3	14966.96	21
MDCVRP-1739	2.57%	13	15	16164.03	267
MDCVRP-1765	0.22%	22	51	18555.84	937
MDCVRP-1799	2.72%	27	75	13597.45	1282
MDCVRP-1832	1.88%	36	79	9069.13	885
MDCVRP-1850	0.17%	37	67	11711.82	640
MDCVRP-1908	3.28%	11	7	18673.75	62
MDCVRP-1910	0.16%	44	77	17543.72	994
MDCVRP-1933	2.22%	13	3	17343.24	24
MDCVRP-1963	7.95%	31	27	11507.00	393
MDCVRP-2014	1.03%	32	21	11015.82	242
MDCVRP-2035	2.90%	16	185	11039.82	1333
MDCVRP-2055	3.26%	37	15	9580.49	776
MDCVRP-2084	0.40%	43	21	9135.65	338
MDCVRP-2095	0.68%	51	21	8987.88	261

Instance	Rg (%)	Rt (s)	Nodes	OPT	t (s)
MDCVRP-2136	0.98%	23	81	9109.73	2897
MDCVRP-2253	6.47%	10	7	18608.38	82
MDCVRP-2315	5.32%	13	9	11000.87	122
MDCVRP-2317	0.50%	65	5	10443.01	145
MDCVRP-2336	0.40%	68	37	10434.83	790
MDCVRP-2347	6.88%	18	89	12266.93	1361
MDCVRP-2355	0.17%	78	5	11181.37	172
MDCVRP-2423	7.26%	19	727	12134.41	5752
MDCVRP-2436	2.90%	23	161	10898.42	4983
MDCVRP-2448	2.45%	20	53	10947.31	1836
MDCVRP-2456	3.39%	49	7	8911.51	294
MDCVRP-2459	4.24%	25	189	10815.62	2751
MDCVRP-2460	7.54%	30	111	11394.43	3076
MDCVRP-2463	3.62%	34	19	11443.10	188
MDCVRP-2485	4.35%	21	13	10914.65	691
MDCVRP-2490	4.47%	30	5	10900.54	86
MDCVRP-2538	3.30%	33	251	11528.30	4971
MDCVRP-2543	0.51%	40	181	7860.02	4444
MDCVRP-2556	2.22%	25	81	10936.53	2353
MDCVRP-2565	2.57%	25	17	10978.89	189
MDCVRP-2594	2.11%	20	27	10560.02	764
MDCVRP-2608	2.78%	27	13	10894.13	364
MDCVRP-2621	2.32%	22	247	21173.52	8729
MDCVRP-2636	5.43%	27	37	19835.73	430
MDCVRP-2641	1.87%	28	3	21073.55	35
MDCVRP-2651	3.52%	30	9	17369.17	153
MDCVRP-2687	0.20%	31	281	21133.94	6823
MDCVRP-2726	0.31%	61	7	13837.23	195
MDCVRP-2767	5.96%	31	17	10222.75	334
MDCVRP-2769	0.16%	71	5	6488.16	204

Instance	Rg (%)	Rt (s)	Nodes	OPT	t (s)
MDCVRP-2771	3.21%	16	23	12821.29	425
MDCVRP-2784	1.32%	35	41	10446.79	892
MDCVRP-2805	6.10%	11	17	9661.41	255
MDCVRP-2814	1.40%	31	87	10506.75	3394
MDCVRP-2880	6.93%	29	37	12210.07	537
MDCVRP-2898	2.79%	33	9	10977.58	200
MDCVRP-2946	0.08%	87	5	14977.40	178
MDCVRP-2957	7.97%	27	13	22349.56	470
MDCVRP-2970	3.45%	40	3	17419.64	68
MDCVRP-2984	0.09%	27	3	17459.90	338
MDCVRP-3006	0.09%	21	11	15067.69	211
MDCVRP-3025	4.50%	11	39	18645.81	964
MDCVRP-3035	0.19%	32	63	20058.83	737
MDCVRP-3040	4.12%	12	9	14953.18	187
MDCVRP-3076	4.38%	22	5	10950.35	49
MDCVRP-3080	4.97%	39	45	10319.53	379
MDCVRP-3089	5.81%	18	19	7113.93	379
MDCVRP-3093	1.92%	38	33	12450.04	637
MDCVRP-3109	2.68%	12	239	9717.28	2477
MDCVRP-3128	8.03%	12	25	7711.85	272
MDCVRP-3141	7.84%	18	9	7782.68	188
MDCVRP-3147	8.21%	15	11	7175.18	159
MDCVRP-3151	5.60%	16	21	7171.69	365
MDCVRP-3160	0.18%	72	5	6538.21	193
MDCVRP-3162	0.55%	38	265	7167.42	6171
MDCVRP-3174	4.68%	17	59	7166.31	1448
MDCVRP-3185	0.78%	60	199	9799.32	2507
MDCVRP-3196	8.14%	17	177	7698.86	3700
MDCVRP-3237	6.16%	42	37	10195.02	885
MDCVRP-3240	3.29%	36	121	11507.56	2298

Instance	Rg (%)	Rt (s)	Nodes	OPT	t (s)
MDCVRP-3274	4.50%	27	25	11536.16	1548
MDCVRP-3275	1.94%	42	19	10956.41	1189
MDCVRP-3324	0.32%	20	19	7832.43	709
MDCVRP-3326	0.35%	49	13	9722.02	171
MDCVRP-3350	6.10%	28	49	19920.29	482
MDCVRP-3354	7.16%	24	13	22365.66	281
MDCVRP-3357	0.28%	34	55	21226.58	761
MDCVRP-3360	2.75%	33	143	18772.84	8454
MDCVRP-3367	7.24%	14	85	16161.18	1558
MDCVRP-3385	7.30%	13	7	16154.08	74
MDCVRP-3397	4.37%	25	23	21227.42	391
MDCVRP-3403	2.90%	35	27	21109.44	876
MDCVRP-3413	7.57%	23	29	23426.59	409
MDCVRP-3422	0.14%	28	19	20051.45	209
MDCVRP-3430	0.14%	29	73	17329.23	936
MDCVRP-3431	0.26%	67	149	17454.82	2463
MDCVRP-3437	5.03%	12	7	16118.20	87
MDCVRP-3448	2.95%	28	85	22292.76	1687
MDCVRP-3453	3.53%	12	5	17386.94	55
MDCVRP-3508	0.98%	20	23	10377.62	1179
MDCVRP-3518	0.00%	40	1	7088.59	39
MDCVRP-3526	2.95%	19	5	10260.44	178
MDCVRP-3534	0.23%	113	7	6530.05	203
MDCVRP-3537	0.26%	67	3	6495.48	96
MDCVRP-3544	2.89%	28	3	10238.41	42
MDCVRP-3608	4.35%	16	7	7202.53	108
MDCVRP-3643	4.47%	18	9	7182.04	184
MDCVRP-3660	0.22%	26	3	7109.64	64

Table EC.7 contains instances for which the initial primal bound has not been proven optimal before these experiments.

Table EC.7: Detailed results for algorithm BCP_{best} for 16 instances of the VRP-CMD with unknown optimal solutions

Instance	IPB	Rg (%)	Rt (s)	Nodes	Fg (%)	BPB	t (s)
MDCVRP-87	10521.07	10.48%	28	2563	0.87%	10410.72	108000
MDCVRP-235	11144.42	4.44%	22	473	0.00%	11112.75	34508
MDCVRP-453	21285.26	3.36%	23	1749	0.28%	21279.71	108000
MDCVRP-487	21352.94	3.62%	24	203	0.00%	21255.48	12772
MDCVRP-528	18679.39	4.46%	19	629	0.00%	18679.39	14241
MDCVRP-582	23660.82	8.59%	18	575	0.00%	23660.82	17636
MDCVRP-599	23579.35	8.53%	25	2639	0.25%	23578.14	108000
MDCVRP-612	23708.73	8.65%	20	3591	0.17%	23708.73	108000
MDCVRP-653	9200.66	3.02%	60	491	0.00%	9200.59	37617
MDCVRP-1280	23567.65	10.47%	23	5913	0.36%	23520.74	108000
MDCVRP-1541	10231.13	6.42%	47	1075	0.00%	10231.13	12851
MDCVRP-2313	11069.50	2.16%	16	1267	0.00%	11069.50	13915
MDCVRP-2431	11551.42	4.10%	35	837	0.00%	11470.91	49199
MDCVRP-2444	10288.95	8.57%	13	2381	4.19%	10288.95	108000
MDCVRP-2734	22379.58	3.74%	20	5899	0.00%	22372.04	96868
MDCVRP-2745	19920.04	5.41%	26	6587	0.39%	19920.04	108000

EC.4. Detailed results for VRPTW with Shifts

In the following tables, BKS stands for the best-known solution value in the literature, RDB for the root dual bound, Rt for the time spent in the root node, Nodes for the number of nodes explored in the branch-and-bound tree, BDB for the best found dual bound, BPB for the best primal bound, and t for the total time. Improved solution values in comparison with the literature are in bold. If

the best bounds are equal then the instances are solved to optimality. Sometimes the total solution time is smaller than the time limit of 30 hours, but the best dual and primal bounds are not equal. In this case, the algorithm was interrupted due to a very large solution time of the labeling algorithm.

Table EC.8: Detailed results for algorithm BCP_{all} without initial upper bounds on instances of the VRPTW-S with small shift capacities ($\rho = 1.05$)

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
A-25-c101	287.2	283.2	11	3	287.2	287.2	16
A-25-c102	263.8	263.8	9	1	263.8	263.8	9
A-25-c103	251.8	251.8	6	1	251.8	251.8	5
A-25-c104	249.2	249.2	22	1	249.2	249.2	22
A-25-c105	265.0	263.5	4	3	265.0	265.0	7
A-25-c106	287.2	282.8	12	3	287.2	287.2	18
A-25-c107	265.0	263.2	9	3	265.0	265.0	14
A-25-c108	263.2	261.5	9	3	263.2	263.2	19
A-25-c109	256.5	256.5	11	1	256.5	256.5	11
A-25-c201	288.9	288.9	6	1	288.9	288.9	6
A-25-c202	281.7	281.7	3	1	281.7	281.7	3
A-25-c203	279.3	279.3	3	1	279.3	279.3	3
A-25-c204	279.3	279.3	5	1	279.3	279.3	5
A-25-c205	288.9	288.9	3	1	288.9	288.9	3
A-25-c206	286.7	286.7	2	1	286.7	286.7	1
A-25-c207	284.0	284.0	3	1	284.0	284.0	3
A-25-c208	285.9	285.9	4	1	285.9	285.9	4
A-25-r101	710.9	710.9	0	1	710.9	710.9	0
A-25-r102	580.7	577.1	3	3	580.7	580.7	5
A-25-r103	504.7	496.5	5	3	504.7	504.7	29
A-25-r104	483.6	475.9	4	3	483.6	483.6	10
A-25-r105	596.8	596.8	2	1	596.8	596.8	2

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
A-25-r106	490.4	490.4	5	1	490.4	490.4	5
A-25-r107	457.2	454.0	6	3	457.2	457.2	11
A-25-r108	437.7	437.7	7	1	437.7	437.7	7
A-25-r109	497.3	492.7	4	3	497.3	497.3	6
A-25-r110	467.1	458.7	7	3	467.1	467.1	11
A-25-r111	471.7	467.0	6	3	471.7	471.7	11
A-25-r112	427.9	420.8	9	3	427.9	427.9	19
A-25-r201	502.1	502.1	6	1	502.1	502.1	6
A-25-r202	437.8	435.8	7	3	437.8	437.8	17
A-25-r203	404.0	404.0	3	1	404.0	404.0	3
A-25-r204	375.4	375.4	2	1	375.4	375.4	2
A-25-r205	421.2	417.4	9	3	421.2	421.2	17
A-25-r206	384.2	384.2	2	1	384.2	384.2	2
A-25-r207	375.4	375.4	2	1	375.4	375.4	2
A-25-r208	367.4	367.4	4	1	367.4	367.4	4
A-25-r209	383.7	383.7	2	1	383.7	383.7	2
A-25-r210	421.5	421.5	3	1	421.5	421.5	3
A-25-r211	364.9	364.9	2	1	364.9	364.9	2
A-25-rc101	608.7	600.4	1	1	600.4	600.4	1
A-25-rc102	470.4	454.8	11	3	470.4	470.4	17
A-25-rc103	427.8	427.8	15	1	427.8	427.8	15
A-25-rc104	410.3	397.7	32	1	397.7	397.7	32
A-25-rc105	535.6	534.7	4	3	535.6	535.6	6
A-25-rc106	472.9	472.9	2	1	472.9	472.9	2
A-25-rc107	434.8	434.8	4	1	434.8	434.8	4
A-25-rc108	∞	383.7	41	3	397.0	397.0	81
A-25-rc201	496.4	478.5	11	1	478.5	478.5	11
A-25-rc202	381.0	381.0	13	1	381.0	381.0	13
A-25-rc203	367.1	361.9	18	1	361.9	361.9	18
A-25-rc204	∞	334.7	85	1	334.7	334.7	84

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
A-25-rc205	376.3	376.3	9	1	376.3	376.3	9
A-25-rc206	369.5	369.5	8	1	369.5	369.5	7
A-25-rc207	337.2	337.2	83	1	337.2	337.2	83
A-25-rc208	∞	329.5	254	1	329.5	329.5	254
A-50-c101	499.5	487.4	12	3	499.5	499.5	20
A-50-c102	467.5	464.0	9	3	467.5	467.5	19
A-50-c103	∞	457.5	12	3	461.4	461.4	39
A-50-c104	∞	419.0	113	1	419.0	419.0	112
A-50-c105	466.6	462.3	7	3	466.6	466.6	14
A-50-c106	499.5	476.4	9	3	499.5	499.5	34
A-50-c107	464.8	458.9	6	3	464.8	464.8	15
A-50-c108	500.3	456.9	11	3	462.4	462.4	21
A-50-c109	∞	445.3	17	5	454.7	454.7	57
A-50-c201	429.8	429.8	6	1	429.8	429.8	6
A-50-c202	421.5	421.5	59	1	421.5	421.5	59
A-50-c203	∞	414.1	79	1	414.1	414.1	79
A-50-c204	∞	402.5	484	3	403.2	403.2	1544
A-50-c205	427.8	427.8	12	1	427.8	427.8	12
A-50-c206	427.8	427.8	15	1	427.8	427.8	15
A-50-c207	∞	425.7	55	3	426.1	426.1	101
A-50-c208	424.2	422.5	35	3	422.7	422.7	65
A-50-r101	1217.3	1209.8	4	3	1217.3	1217.3	6
A-50-r102	980.6	975.8	4	3	980.6	980.6	10
A-50-r103	820.3	812.3	10	3	820.3	820.3	49
A-50-r104	664.6	662.2	16	3	664.6	664.6	43
A-50-r105	1037.9	1036.2	5	3	1037.9	1037.9	11
A-50-r106	875.6	870.5	6	3	875.6	875.6	16
A-50-r107	777.0	763.1	8	7	773.8	773.8	104
A-50-r108	644.8	638.1	55	3	644.8	644.8	140
A-50-r109	891.3	838.8	8	3	852.3	852.3	58

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
A-50-r110	749.0	741.4	14	3	749.0	749.0	38
A-50-r111	752.4	749.4	14	3	752.4	752.4	28
A-50-r112	665.1	659.2	48	3	665.1	665.1	123
A-50-r201	∞	834.2	10	7	844.1	844.1	95
A-50-r202	732.7	729.6	37	3	732.7	732.7	80
A-50-r203	632.3	627.6	92	3	632.3	632.3	258
A-50-r204	∞	528.3	356	3	530.0	530.0	1208
A-50-r205	716.4	713.4	44	3	716.4	716.4	86
A-50-r206	649.6	648.6	104	3	649.6	649.6	334
A-50-r207	587.8	587.5	337	3	587.8	587.8	1059
A-50-r208	∞	502.4	53	1	502.4	502.4	53
A-50-r209	619.1	616.2	94	3	619.1	619.1	182
A-50-r210	657.0	657.0	193	1	657.0	657.0	193
A-50-r211	541.5	541.5	125	1	541.5	541.5	124
A-50-rc101	1174.1	1131.1	7	3	1136.8	1136.8	8
A-50-rc102	975.8	951.7	23	3	973.6	973.6	39
A-50-rc103	∞	824.8	38	3	836.5	836.5	91
A-50-rc104	∞	669.7	110	3	697.4	697.4	520
A-50-rc105	∞	1043.6	40	1	1043.6	1043.6	45
A-50-rc106	∞	939.5	50	3	956.1	956.1	90
A-50-rc107	∞	766.2	501	1	766.2	766.2	501
A-50-rc108	∞	664.1	272	21	724.3	724.3	4640
A-50-rc201	∞	809.6	51	3	828.6	828.6	122
A-50-rc202	∞	711.2	242	1	711.2	711.2	242
A-50-rc203	∞	645.2	346	3	654.4	654.4	883
A-50-rc204	∞	497.7	377	13	533.3	533.3	4390
A-50-rc205	717.7	717.7	53	1	717.7	717.7	53
A-50-rc206	∞	662.9	135	3	669.1	669.1	205
A-50-rc207	∞	588.1	306	21	617.0	617.0	6180
A-50-rc208	∞	482.3	336	17	510.4	510.4	6503

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
A-100-c101	1114.5	1109.1	23	3	1114.5	1114.5	40
A-100-c102	1036.3	1033.3	41	3	1036.3	1036.3	77
A-100-c103	∞	1010.0	104	1	1010.0	1010.0	104
A-100-c104	∞	935.4	552	5	943.6	943.6	4518
A-100-c105	1071.6	1063.8	18	3	1071.6	1071.6	43
A-100-c106	∞	1072.5	27	3	1078.9	1078.9	61
A-100-c107	1030.6	1030.6	14	1	1030.6	1030.6	13
A-100-c108	1029.3	1029.3	25	1	1029.3	1029.3	32
A-100-c109	∞	977.3	49	7	995.1	995.1	287
A-100-c201	∞	675.2	113	3	683.6	683.6	341
A-100-c202	∞	672.9	348	3	678.5	678.5	737
A-100-c203	∞	663.0	710	3	669.1	669.1	1383
A-100-c204	∞	630.8	864	1	630.8	∞	6578
A-100-c205	∞	660.8	125	5	674.1	674.1	479
A-100-c206	∞	656.6	171	3	664.1	664.1	349
A-100-c207	∞	653.1	255	3	663.9	663.9	743
A-100-c208	∞	649.8	488	3	660.9	660.9	967
A-100-r101	1840.6	1832.4	11	3	1840.6	1840.6	38
A-100-r102	1535.4	1534.2	17	3	1535.4	1535.4	40
A-100-r103	∞	1222.9	29	3	1223.7	1223.7	86
A-100-r104	∞	1001.2	197	27	1009.0	1009.0	5793
A-100-r105	1465.2	1459.4	20	3	1465.2	1465.2	72
A-100-r106	1294.9	1286.5	41	27	1294.9	1294.9	855
A-100-r107	∞	1097.7	66	31	1106.1	1106.1	3544
A-100-r108	∞	955.2	241	421	968.5	968.5	66955
A-100-r109	∞	1225.9	54	17	1237.8	1237.8	1002
A-100-r110	∞	1120.8	141	7	1126.8	1126.8	597
A-100-r111	∞	1093.0	90	13	1100.6	1100.6	996
A-100-r112	∞	982.9	400	11	987.2	987.2	3741
A-100-r201	1188.5	1184.4	163	7	1188.5	1188.5	694

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
A-100-r202	∞	1039.6	386	21	1044.2	1044.2	7738
A-100-r203	∞	882.3	1282	35	889.9	889.9	19393
A-100-r204	∞	724.5	970	173	728.4	775.5	108002
A-100-r205	∞	962.3	435	33	973.0	973.0	11826
A-100-r206	∞	876.3	638	217	879.1	933.5	108004
A-100-r207	∞	793.1	690	1	793.1	∞	2640
A-100-r208	∞	690.6	1041	1	690.6	∞	3303
A-100-r209	∞	855.3	534	83	871.5	871.5	34124
A-100-r210	∞	896.8	548	137	904.5	904.5	63478
A-100-r211	∞	735.7	618	39	738.1	∞	26075
A-100-rc101	1877.3	1847.1	29	3	1853.0	1853.0	83
A-100-rc102	1598.6	1581.6	84	11	1596.0	1596.0	453
A-100-rc103	∞	1349.4	142	11	1362.7	1362.7	1290
A-100-rc104	∞	1181.8	262	9	1205.4	1205.4	2640
A-100-rc105	1720.7	1705.8	63	3	1712.5	1712.5	139
A-100-rc106	∞	1513.3	81	9	1518.8	1518.8	334
A-100-rc107	∞	1310.7	93	11	1321.9	1321.9	712
A-100-rc108	∞	1186.8	280	305	1209.5	1209.5	78481
A-100-rc201	∞	1290.6	79	9	1298.7	1298.7	641
A-100-rc202	∞	1111.7	205	9	1116.4	1116.4	1791
A-100-rc203	∞	939.6	952	3	944.7	944.7	1873
A-100-rc204	∞	776.9	1583	3	778.7	∞	5049
A-100-rc205	∞	1167.1	225	19	1176.4	1176.4	3132
A-100-rc206	∞	1062.4	309	15	1072.7	1072.7	3349
A-100-rc207	∞	956.6	798	95	970.9	970.9	35039
A-100-rc208	∞	766.2	2496	211	769.4	812.3	108014

Table EC.9: Detailed results for algorithm BCP_{all} without initial upper bounds on instances of the VRPTW-S with medium shift capacities ($\rho = 1.2$)

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
B-25-c101	265.2	265.2	10	1	265.2	265.2	10
B-25-c102	251.6	251.6	10	1	251.6	251.6	10
B-25-c103	247.4	244.4	24	3	247.4	247.4	38
B-25-c104	∞	241.9	56	1	241.9	241.9	56
B-25-c105	258.8	258.8	8	1	258.8	258.8	8
B-25-c106	265.2	265.2	12	1	265.2	265.2	12
B-25-c107	256.6	256.6	6	1	256.6	256.6	6
B-25-c108	256.6	256.6	26	3	256.6	256.6	43
B-25-c109	∞	252.8	75	3	254.8	254.8	137
B-25-c201	279.6	279.6	2	1	279.6	279.6	2
B-25-c202	272.9	272.9	3	1	272.9	272.9	3
B-25-c203	269.9	269.9	3	1	269.9	269.9	3
B-25-c204	269.9	269.9	6	1	269.9	269.9	6
B-25-c205	279.6	279.6	3	1	279.6	279.6	3
B-25-c206	277.4	277.4	2	1	277.4	277.4	2
B-25-c207	274.5	274.5	4	1	274.5	274.5	4
B-25-c208	276.6	276.6	3	1	276.6	276.6	3
B-25-r101	671.9	671.9	0	1	671.9	671.9	0
B-25-r102	557.4	556.1	3	3	557.4	557.4	5
B-25-r103	478.2	476.5	3	3	478.2	478.2	7
B-25-r104	451.8	451.8	4	1	451.8	451.8	4
B-25-r105	566.4	565.6	1	1	565.6	565.6	1
B-25-r106	483.2	474.4	6	3	483.2	483.2	9
B-25-r107	443.3	443.3	3	1	443.3	443.3	3
B-25-r108	426.9	426.9	4	1	426.9	426.9	4
B-25-r109	481.7	472.6	4	3	481.7	481.7	6
B-25-r110	451.9	448.1	5	3	451.9	451.9	9

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
B-25-r111	461.3	455.5	4	3	461.3	461.3	9
B-25-r112	405.9	405.9	5	1	405.9	405.9	5
B-25-r201	496.4	491.3	6	3	496.4	496.4	12
B-25-r202	429.4	423.4	4	3	429.4	429.4	10
B-25-r203	395.9	395.9	3	1	395.9	395.9	3
B-25-r204	368.3	368.3	4	1	368.3	368.3	4
B-25-r205	402.6	402.6	1	1	402.6	402.6	1
B-25-r206	382.0	382.0	4	1	382.0	382.0	3
B-25-r207	363.1	363.1	1	1	363.1	363.1	1
B-25-r208	356.5	356.5	1	1	356.5	356.5	1
B-25-r209	376.4	376.4	1	1	376.4	376.4	1
B-25-r210	413.1	413.1	3	1	413.1	413.1	3
B-25-r211	361.6	361.6	3	1	361.6	361.6	3
B-25-rc101	534.9	534.9	1	1	534.9	534.9	1
B-25-rc102	417.7	417.7	3	1	417.7	417.7	3
B-25-rc103	398.7	398.7	6	1	398.7	398.7	6
B-25-rc104	368.3	368.3	11	1	368.3	368.3	11
B-25-rc105	483.7	479.1	2	3	483.7	483.7	4
B-25-rc106	467.8	456.4	5	3	460.7	460.7	7
B-25-rc107	∞	409.5	24	3	430.0	430.0	37
B-25-rc108	369.8	363.4	27	1	363.4	363.4	27
B-25-rc201	446.6	429.2	6	1	429.2	429.2	6
B-25-rc202	338.0	338.0	1	1	338.0	338.0	1
B-25-rc203	326.9	326.9	2	1	326.9	326.9	2
B-25-rc204	299.7	299.7	2	1	299.7	299.7	2
B-25-rc205	338.0	338.0	1	1	338.0	338.0	1
B-25-rc206	334.4	334.4	1	1	334.4	334.4	1
B-25-rc207	298.3	298.3	1	1	298.3	298.3	1
B-25-rc208	294.5	294.5	3	1	294.5	294.5	3
B-50-c101	455.1	431.3	5	1	431.3	431.3	5

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
B-50-c102	442.1	425.8	11	3	428.3	428.3	25
B-50-c103	424.3	422.9	13	3	424.3	424.3	34
B-50-c104	∞	395.0	260	9	409.0	409.0	3362
B-50-c105	428.9	424.4	7	3	428.9	428.9	16
B-50-c106	431.3	431.3	6	1	431.3	431.3	6
B-50-c107	425.7	423.7	10	3	425.7	425.7	22
B-50-c108	424.5	421.3	8	3	424.5	424.5	20
B-50-c109	∞	416.7	25	3	421.8	421.8	49
B-50-c201	412.3	412.3	4	1	412.3	412.3	4
B-50-c202	407.2	406.7	59	3	407.2	407.2	95
B-50-c203	400.0	396.7	49	1	396.7	396.7	49
B-50-c204	∞	390.3	144	1	390.3	390.3	144
B-50-c205	411.9	411.9	5	1	411.9	411.9	5
B-50-c206	411.9	411.9	12	1	411.9	411.9	12
B-50-c207	∞	408.3	72	3	411.7	411.7	131
B-50-c208	402.6	402.6	8	1	402.6	402.6	8
B-50-r101	1136.4	1131.6	4	3	1136.4	1136.4	5
B-50-r102	933.7	930.7	4	3	933.7	933.7	9
B-50-r103	792.9	787.0	10	3	792.9	792.9	24
B-50-r104	650.0	642.0	39	3	650.0	650.0	123
B-50-r105	982.0	973.2	4	3	979.1	979.1	10
B-50-r106	841.0	836.7	7	3	841.0	841.0	17
B-50-r107	741.7	737.0	16	3	741.7	741.7	38
B-50-r108	∞	620.7	101	3	628.2	628.2	321
B-50-r109	817.9	813.5	10	3	817.9	817.9	19
B-50-r110	733.9	725.7	13	3	733.9	733.9	32
B-50-r111	733.1	730.5	20	3	733.1	733.1	41
B-50-r112	649.4	646.7	45	3	649.4	649.4	86
B-50-r201	819.7	815.6	12	3	819.7	819.7	25
B-50-r202	730.6	717.5	40	3	720.6	720.6	76

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
B-50-r203	619.3	616.9	79	3	619.3	619.3	177
B-50-r204	∞	520.9	220	3	521.1	521.1	445
B-50-r205	705.0	698.8	42	5	705.0	705.0	173
B-50-r206	663.4	643.2	135	3	647.3	647.3	337
B-50-r207	582.7	582.7	322	1	582.7	582.7	322
B-50-r208	∞	498.5	60	1	498.5	498.5	60
B-50-r209	611.3	609.0	55	3	611.3	611.3	126
B-50-r210	656.6	653.4	176	3	656.6	656.6	435
B-50-r211	536.9	536.9	139	1	536.9	536.9	139
B-50-rc101	1098.6	1034.4	6	3	1051.1	1051.1	15
B-50-rc102	912.1	909.0	31	3	910.0	910.0	49
B-50-rc103	∞	768.7	54	3	783.3	783.3	96
B-50-rc104	∞	628.0	124	3	631.8	631.8	361
B-50-rc105	∞	964.6	45	3	965.8	965.8	62
B-50-rc106	∞	866.7	45	3	886.7	886.7	87
B-50-rc107	∞	718.8	359	3	726.7	726.7	824
B-50-rc108	∞	624.5	170	11	700.7	700.7	2351
B-50-rc201	809.8	764.4	42	3	782.2	782.2	76
B-50-rc202	690.7	669.4	40	3	672.3	672.3	73
B-50-rc203	∞	610.4	72	1	610.4	610.4	72
B-50-rc204	∞	476.1	411	17	504.7	504.7	5281
B-50-rc205	680.3	680.3	15	1	680.3	680.3	15
B-50-rc206	636.0	614.5	34	5	636.0	636.0	227
B-50-rc207	∞	561.8	146	37	582.5	582.5	5441
B-50-rc208	∞	469.2	383	157	496.7	496.7	48087
B-100-c101	991.8	984.9	27	3	991.8	991.8	67
B-100-c102	∞	954.2	42	3	955.2	955.2	97
B-100-c103	∞	942.9	149	9	949.2	949.2	506
B-100-c104	∞	897.1	359	5	904.7	904.7	4432
B-100-c105	964.6	961.4	21	3	964.6	964.6	44

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
B-100-c106	972.4	967.1	36	3	972.4	972.4	70
B-100-c107	954.6	949.6	20	3	954.6	954.6	40
B-100-c108	∞	948.6	32	3	954.5	954.5	62
B-100-c109	∞	909.6	46	9	911.2	911.2	277
B-100-c201	∞	662.9	278	3	671.7	671.7	462
B-100-c202	∞	656.4	461	5	667.6	667.6	1188
B-100-c203	∞	645.2	900	9	655.6	655.6	4088
B-100-c204	∞	624.4	1573	1	624.4	681.3	3443
B-100-c205	∞	653.8	233	9	668.6	668.6	1088
B-100-c206	∞	643.8	256	11	664.1	664.1	1339
B-100-c207	∞	639.6	308	3	647.2	647.2	616
B-100-c208	∞	633.8	388	13	647.9	647.9	2632
B-100-r101	1721.6	1708.3	14	3	1715.7	1715.7	33
B-100-r102	1499.5	1498.6	18	3	1499.5	1499.5	45
B-100-r103	∞	1199.4	42	3	1201.5	1201.5	108
B-100-r104	1391.3	978.0	229	33	985.8	985.8	6548
B-100-r105	∞	1390.2	22	3	1391.3	1391.3	42
B-100-r106	∞	1260.3	43	9	1266.1	1266.1	415
B-100-r107	∞	1071.5	96	11	1077.6	1077.6	1348
B-100-r108	∞	931.6	282	9	942.0	942.0	2686
B-100-r109	∞	1188.0	64	37	1199.1	1199.1	2054
B-100-r110	∞	1091.7	153	7	1095.3	1095.3	675
B-100-r111	∞	1065.1	75	3	1065.5	1065.5	136
B-100-r112	∞	964.4	398	57	975.7	975.7	16094
B-100-r201	1167.7	1164.2	98	5	1167.7	1167.7	269
B-100-r202	∞	1031.9	460	5	1035.6	1035.6	2381
B-100-r203	∞	869.5	632	63	879.2	879.2	32406
B-100-r204	∞	723.5	1099	137	727.4	796.8	108022
B-100-r205	∞	954.4	530	59	965.0	965.0	21217
B-100-r206	∞	868.3	655	265	874.2	892.7	108004

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
B-100-r207	∞	790.7	1023	3	790.7	∞	5294
B-100-r208	∞	689.5	1306	7	691.5	∞	8418
B-100-r209	∞	851.2	718	183	853.4	∞	108012
B-100-r210	∞	893.1	583	13	900.5	900.5	6977
B-100-r211	∞	735.0	834	1	735.0	∞	2701
B-100-rc101	1759.4	1730.1	31	3	1738.2	1738.2	87
B-100-rc102	1532.9	1513.5	112	5	1520.8	1520.8	295
B-100-rc103	∞	1294.8	171	3	1302.1	1302.1	395
B-100-rc104	∞	1143.4	262	21	1158.2	1158.2	3695
B-100-rc105	1662.1	1614.0	61	3	1617.8	1617.8	131
B-100-rc106	∞	1435.7	79	7	1442.9	1442.9	268
B-100-rc107	∞	1263.7	97	9	1274.7	1274.7	717
B-100-rc108	∞	1152.9	285	15	1166.3	1166.3	3922
B-100-rc201	1279.8	1275.8	82	3	1279.8	1279.8	149
B-100-rc202	1116.5	1101.1	238	13	1110.4	1110.4	1863
B-100-rc203	∞	926.7	707	1	926.7	974.9	1947
B-100-rc204	∞	771.8	2407	3	773.3	∞	6659
B-100-rc205	∞	1156.8	268	3	1157.6	1157.6	405
B-100-rc206	∞	1050.9	287	3	1059.1	1059.1	590
B-100-rc207	∞	953.4	700	59	968.6	968.6	25852
B-100-rc208	∞	763.5	2547	9	766.8	∞	13638

Table EC.10: Detailed results for algorithm BCP_{all} without initial upper bounds on instances of the VRPTW-S with large shift capacities ($\rho = 1.5$)

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
C-25-c101	213.4	208.0	8	3	213.4	213.4	13
C-25-c102	212.4	207.0	15	3	212.4	212.4	27

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
C-25-c103	207.5	206.5	15	3	207.5	207.5	25
C-25-c104	204.4	200.9	11	3	204.4	204.4	24
C-25-c105	213.4	206.9	3	3	213.4	213.4	8
C-25-c106	213.4	208.0	11	3	213.4	213.4	17
C-25-c107	213.4	206.9	4	3	213.4	213.4	8
C-25-c108	213.4	206.9	4	3	213.4	213.4	8
C-25-c109	229.5	206.5	8	3	213.4	213.4	14
C-25-c201	252.1	252.1	5	1	252.1	252.1	5
C-25-c202	247.1	247.1	5	1	247.1	247.1	5
C-25-c203	244.5	244.5	6	1	244.5	244.5	6
C-25-c204	243.0	243.0	11	1	243.0	243.0	11
C-25-c205	251.3	251.3	5	1	251.3	251.3	5
C-25-c206	248.7	248.7	3	1	248.7	248.7	2
C-25-c207	245.5	245.5	7	1	245.5	245.5	7
C-25-c208	247.2	247.2	4	1	247.2	247.2	3
C-25-r101	617.1	617.1	0	1	617.1	617.1	0
C-25-r102	547.1	547.1	2	1	547.1	547.1	2
C-25-r103	454.6	454.6	1	1	454.6	454.6	1
C-25-r104	420.8	418.5	3	3	420.8	420.8	8
C-25-r105	551.9	530.7	1	1	530.7	530.7	1
C-25-r106	465.4	465.4	2	1	465.4	465.4	2
C-25-r107	425.8	425.8	1	1	425.8	425.8	0
C-25-r108	404.3	404.3	4	3	404.3	404.3	8
C-25-r109	447.8	445.7	2	3	447.8	447.8	5
C-25-r110	444.1	444.1	4	3	444.1	444.1	7
C-25-r111	428.8	428.8	1	1	428.8	428.8	1
C-25-r112	393.0	393.0	3	1	393.0	393.0	3
C-25-r201	467.7	465.7	4	3	467.7	467.7	9
C-25-r202	410.5	410.5	1	1	410.5	410.5	1
C-25-r203	391.4	391.4	2	1	391.4	391.4	2

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
C-25-r204	366.8	365.6	28	3	366.8	366.8	59
C-25-r205	402.6	400.2	6	3	402.6	402.6	14
C-25-r206	375.9	375.9	3	1	375.9	375.9	3
C-25-r207	361.6	361.6	3	1	361.6	361.6	3
C-25-r208	340.4	340.4	1	1	340.4	340.4	1
C-25-r209	376.4	375.2	8	3	376.4	376.4	22
C-25-r210	404.6	404.6	1	1	404.6	404.6	1
C-25-r211	352.0	352.0	2	1	352.0	352.0	2
C-25-rc101	462.7	462.7	1	1	462.7	462.7	1
C-25-rc102	400.8	400.8	6	1	400.8	400.8	6
C-25-rc103	389.7	388.6	28	1	388.6	388.6	28
C-25-rc104	361.0	361.0	30	1	361.0	361.0	30
C-25-rc105	411.3	411.3	1	1	411.3	411.3	1
C-25-rc106	396.9	396.9	2	1	396.9	396.9	2
C-25-rc107	365.2	362.1	12	3	363.8	363.8	19
C-25-rc108	∞	352.1	28	3	360.0	360.0	56
C-25-rc201	426.0	397.3	4	1	397.3	397.3	3
C-25-rc202	338.0	338.0	1	1	338.0	338.0	1
C-25-rc203	326.9	326.9	1	1	326.9	326.9	1
C-25-rc204	299.7	299.7	3	1	299.7	299.7	3
C-25-rc205	338.0	338.0	1	1	338.0	338.0	1
C-25-rc206	334.4	334.4	2	1	334.4	334.4	1
C-25-rc207	298.3	298.3	2	1	298.3	298.3	2
C-25-rc208	293.1	292.7	14	3	293.1	293.1	25
C-50-c101	400.3	377.9	10	3	384.5	384.5	18
C-50-c102	399.3	376.0	19	3	383.5	383.5	37
C-50-c103	395.0	375.6	17	3	383.5	383.5	36
C-50-c104	∞	369.5	27	3	378.7	378.7	70
C-50-c105	384.5	376.8	8	3	384.5	384.5	18
C-50-c106	384.5	376.8	9	3	384.5	384.5	18

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
C-50-c107	384.5	376.8	8	3	384.5	384.5	21
C-50-c108	389.3	376.7	10	3	384.5	384.5	26
C-50-c109	389.3	375.9	10	3	384.5	384.5	23
C-50-c201	395.9	392.9	45	3	395.9	395.9	104
C-50-c202	383.2	383.2	6	1	383.2	383.2	6
C-50-c203	376.9	376.9	14	1	376.9	376.9	23
C-50-c204	374.1	369.7	203	3	372.2	372.2	894
C-50-c205	389.4	389.4	12	1	389.4	389.4	12
C-50-c206	389.4	389.4	41	1	389.4	389.4	48
C-50-c207	377.1	377.1	13	1	377.1	377.1	13
C-50-c208	386.2	385.4	150	3	386.2	386.2	239
C-50-r101	1049.0	1049.0	3	1	1049.0	1049.0	3
C-50-r102	902.8	902.8	3	1	902.8	902.8	5
C-50-r103	760.6	757.5	7	3	760.6	760.6	17
C-50-r104	636.9	628.2	24	3	629.4	629.4	53
C-50-r105	926.1	906.1	5	3	906.3	906.3	10
C-50-r106	791.6	791.6	6	3	791.6	791.6	17
C-50-r107	720.0	705.4	16	3	708.3	708.3	35
C-50-r108	∞	608.5	95	3	611.1	611.1	303
C-50-r109	791.9	788.3	6	3	791.9	791.9	14
C-50-r110	717.3	705.2	7	1	705.2	705.2	11
C-50-r111	714.0	713.8	15	3	714.0	714.0	27
C-50-r112	657.2	634.7	26	3	637.1	637.1	52
C-50-r201	803.3	800.2	9	3	800.6	800.6	21
C-50-r202	765.4	708.2	26	3	713.8	713.8	53
C-50-r203	617.8	613.8	67	3	615.2	615.2	114
C-50-r204	∞	516.7	302	3	518.4	518.4	627
C-50-r205	690.9	690.9	13	1	690.9	690.9	13
C-50-r206	669.3	634.8	72	3	637.7	637.7	186
C-50-r207	∞	580.3	354	3	581.5	581.5	836

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
C-50-r208	∞	495.6	231	3	498.5	498.5	542
C-50-r209	600.6	600.6	10	1	600.6	600.6	10
C-50-r210	∞	648.2	118	3	651.2	651.2	227
C-50-r211	535.5	535.5	72	1	535.5	535.5	72
C-50-rc101	1066.7	945.6	5	3	954.9	954.9	17
C-50-rc102	854.6	794.5	42	3	833.4	833.4	80
C-50-rc103	716.0	665.4	32	3	714.1	714.1	77
C-50-rc104	∞	573.7	326	3	599.2	599.2	3054
C-50-rc105	913.6	860.2	16	3	894.7	894.7	43
C-50-rc106	768.0	734.2	60	3	767.8	767.8	111
C-50-rc107	712.8	662.0	139	3	672.4	672.4	214
C-50-rc108	∞	580.0	151	3	632.6	632.6	355
C-50-rc201	730.5	716.6	33	1	716.6	716.6	32
C-50-rc202	636.3	631.7	267	3	636.3	636.3	443
C-50-rc203	∞	572.4	722	7	579.1	579.1	2629
C-50-rc204	∞	449.2	565	509	464.3	523.3	108014
C-50-rc205	671.1	652.3	219	3	657.5	657.5	315
C-50-rc206	610.0	610.0	14	1	610.0	610.0	14
C-50-rc207	560.2	560.2	153	1	560.2	560.2	152
C-50-rc208	476.7	459.4	676	53	476.7	476.7	14230
C-100-c101	862.5	830.4	21	3	847.5	847.5	52
C-100-c102	862.5	829.9	33	3	847.5	847.5	83
C-100-c103	∞	828.9	59	3	846.3	846.3	153
C-100-c104	∞	824.2	72	3	842.2	842.2	240
C-100-c105	857.2	829.9	21	3	847.5	847.5	62
C-100-c106	851.5	830.4	25	3	847.5	847.5	79
C-100-c107	857.2	829.9	20	3	847.5	847.5	79
C-100-c108	∞	829.9	30	3	847.5	847.5	85
C-100-c109	∞	828.8	32	3	847.1	847.1	74
C-100-c201	∞	627.0	181	1	627.0	627.0	181

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
C-100-c202	∞	626.0	628	3	626.8	626.8	16349
C-100-c203	∞	617.8	1321	1	617.8	617.8	1320
C-100-c204	∞	591.1	1874	3	617.2	617.2	3730
C-100-c205	∞	623.8	354	3	624.1	624.1	1272
C-100-c206	∞	622.6	509	3	623.7	623.7	3335
C-100-c207	∞	622.1	678	3	622.1	623.5	6739
C-100-c208	∞	616.2	426	1	616.2	616.2	426
C-100-r101	1679.4	1632.0	10	3	1634.8	1634.8	27
C-100-r102	1470.0	1460.4	14	1	1460.4	1460.4	21
C-100-r103	1185.7	1184.8	23	3	1185.0	1185.0	50
C-100-r104	∞	947.3	214	115	955.4	955.4	8530
C-100-r105	1361.4	1355.0	19	3	1355.3	1355.3	65
C-100-r106	1228.0	1227.8	41	15	1228.0	1228.0	211
C-100-r107	1047.1	1045.1	104	5	1047.1	1047.1	577
C-100-r108	∞	911.1	306	3	913.6	913.6	687
C-100-r109	1146.9	1144.3	55	3	1146.9	1146.9	225
C-100-r110	1068.0	1068.0	157	3	1068.0	1068.0	266
C-100-r111	∞	1045.1	136	5	1048.0	1048.0	590
C-100-r112	∞	945.1	446	7	948.6	948.6	3244
C-100-r201	1144.3	1143.2	78	5	1143.6	1143.6	313
C-100-r202	1029.8	1026.1	323	9	1029.8	1029.8	3064
C-100-r203	∞	868.0	1514	5	870.8	870.8	4330
C-100-r204	∞	720.2	1313	97	721.6	747.1	79596
C-100-r205	∞	944.8	519	7	949.8	949.8	3305
C-100-r206	∞	866.5	688	29	870.5	995.5	34344
C-100-r207	∞	783.0	853	85	787.6	827.7	90306
C-100-r208	∞	686.0	2244	25	687.5	∞	32906
C-100-r209	∞	847.6	768	161	850.6	877.6	75146
C-100-r210	∞	893.2	1019	149	895.9	913.1	83470
C-100-r211	∞	736.3	1184	203	738.1	801.4	108000

Instance	BKS	RDB	Rt (s)	Nodes	BDB	BPB	t (s)
C-100-rc101	1685.3	1619.8	22	1	1619.8	1619.8	28
C-100-rc102	1471.9	1442.3	84	1	1442.3	1442.3	97
C-100-rc103	∞	1229.2	114	7	1235.9	1235.9	1085
C-100-rc104	∞	1097.6	252	3	1100.7	1100.7	570
C-100-rc105	1615.5	1513.7	57	1	1513.7	1513.7	68
C-100-rc106	∞	1366.8	171	3	1372.7	1372.7	312
C-100-rc107	1207.8	1205.4	95	1	1205.4	1205.4	117
C-100-rc108	1114.2	1108.5	242	3	1114.2	1114.2	541
C-100-rc201	1261.8	1261.5	97	3	1261.8	1261.8	147
C-100-rc202	1092.3	1092.3	282	1	1092.3	1092.3	314
C-100-rc203	∞	922.7	904	11	925.2	1007.9	9702
C-100-rc204	∞	770.7	9956	29	774.5	880.1	68778
C-100-rc205	1154.0	1152.4	228	3	1154.0	1154.0	419
C-100-rc206	∞	1044.3	298	11	1052.2	1052.2	1955
C-100-rc207	∞	955.2	1061	15	963.2	963.2	6421
C-100-rc208	∞	763.9	2848	77	767.0	800.7	83268